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Shale Plays in the Intermountain West: Legal
and Policy Issues (November 12)

2010

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SLIDES: Water and Development of Unconventional Oil and Gas Resources

Judy Jordan

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Water & Development of Unconventional Oil and Gas Resources

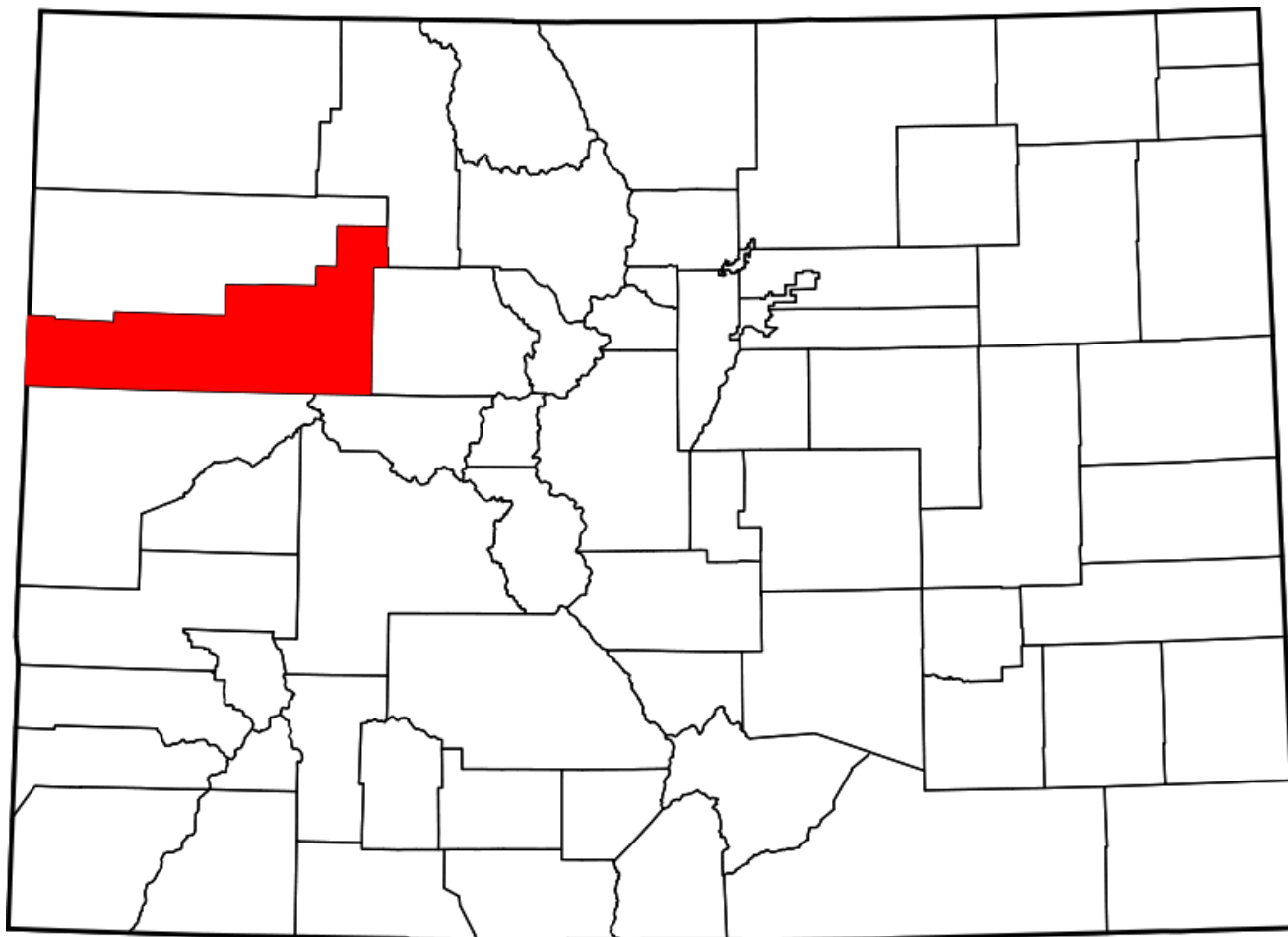
Judy Jordan

Oil and Gas Liaison

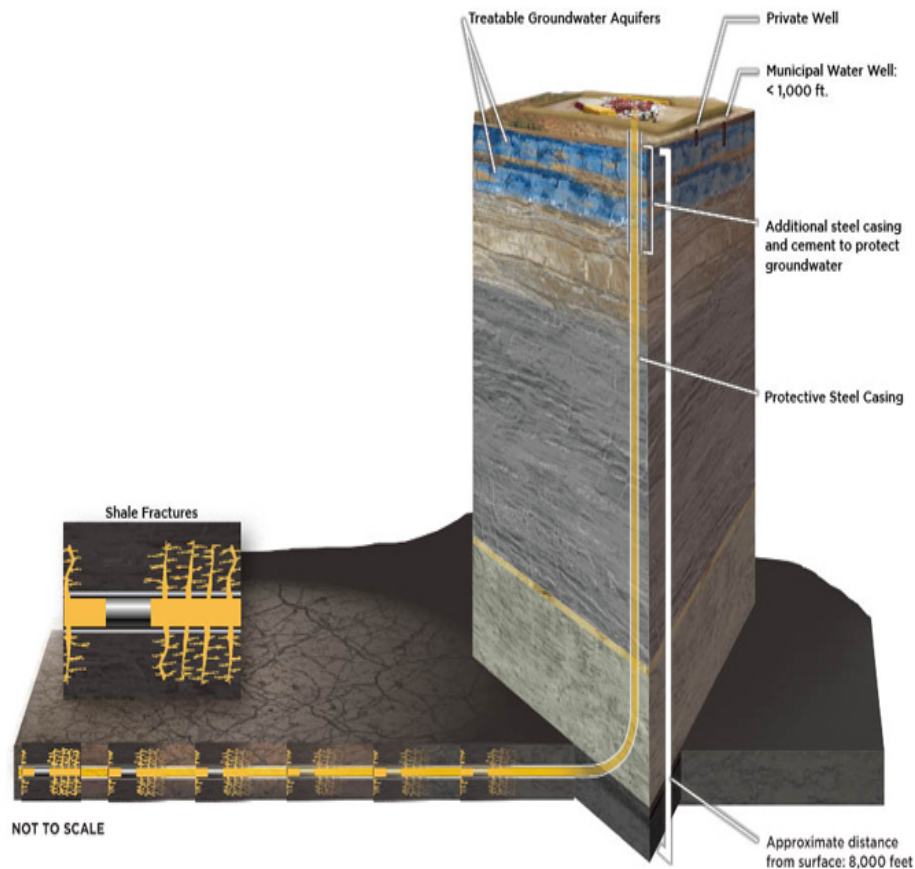
jjordan@garfield-county.com



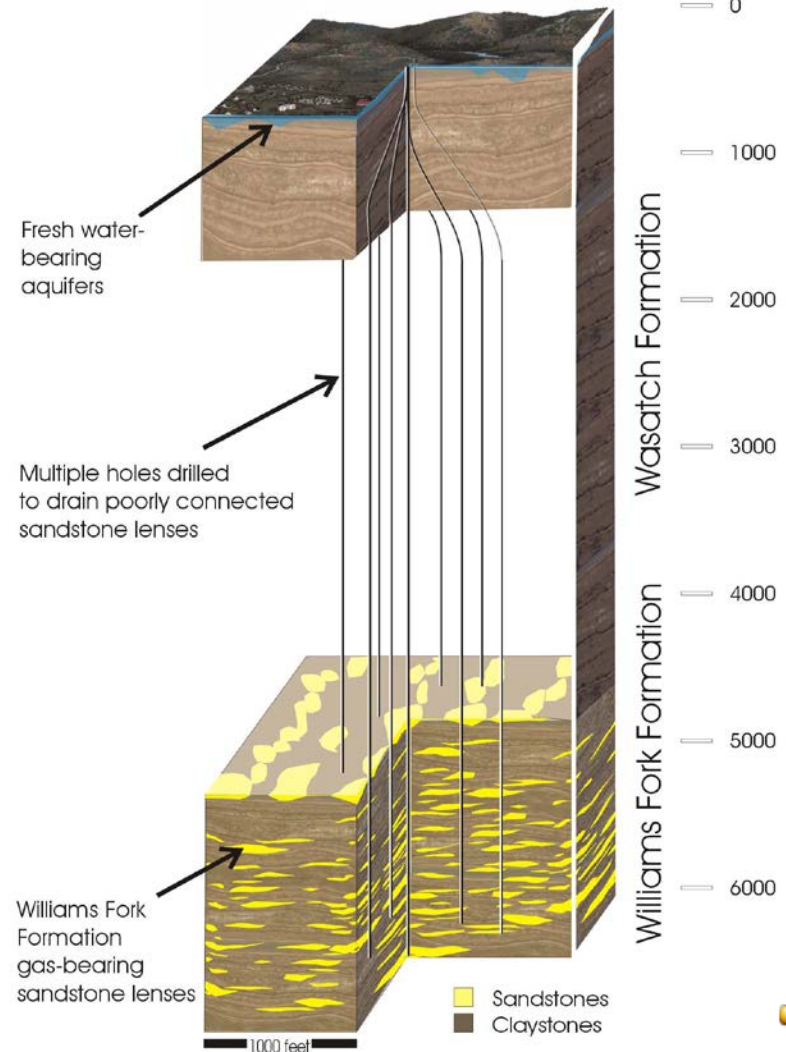
Garfield County, CO



Shales & tight Sands -directional drilling, fracing, deep (2000-15,000')

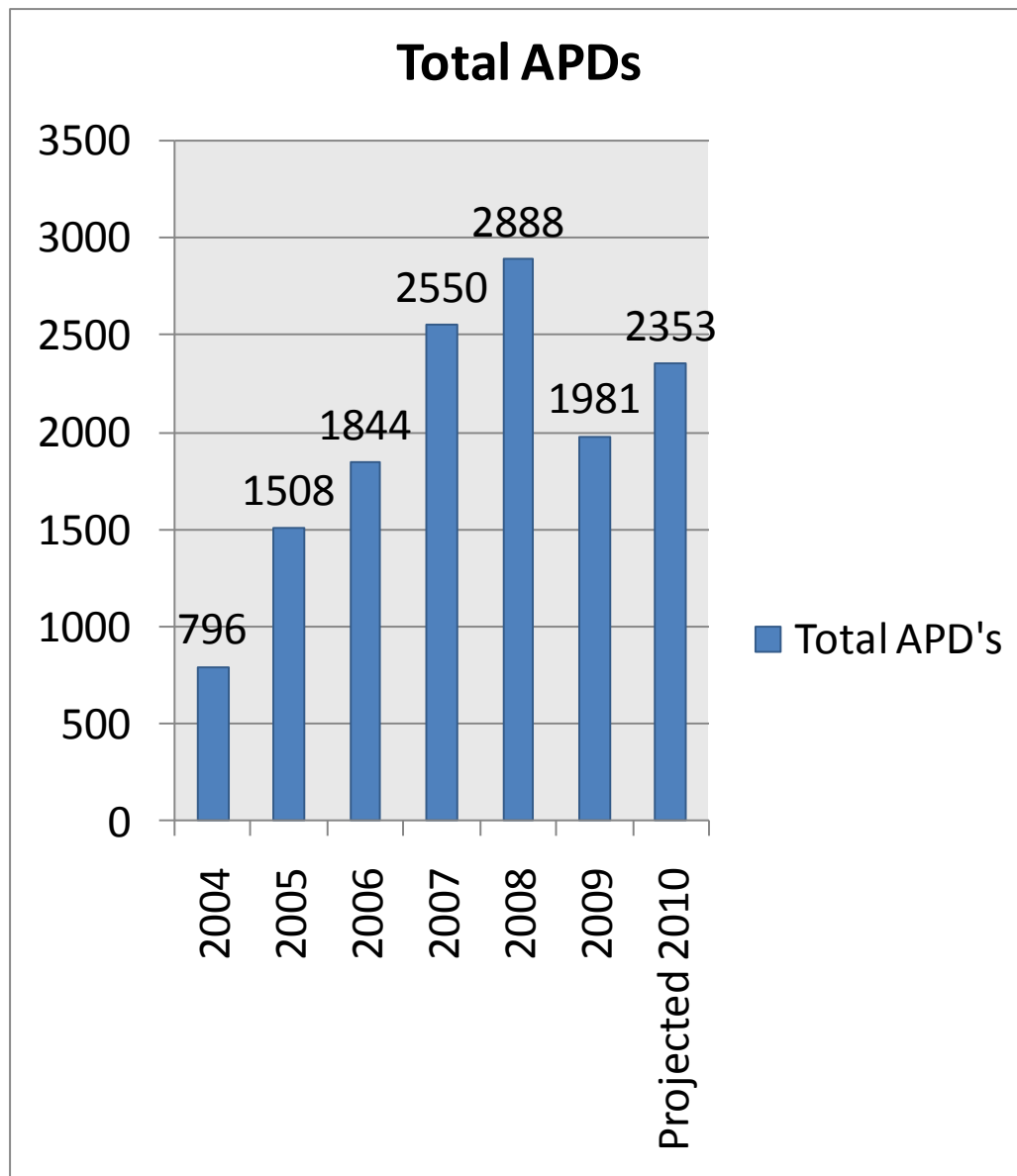


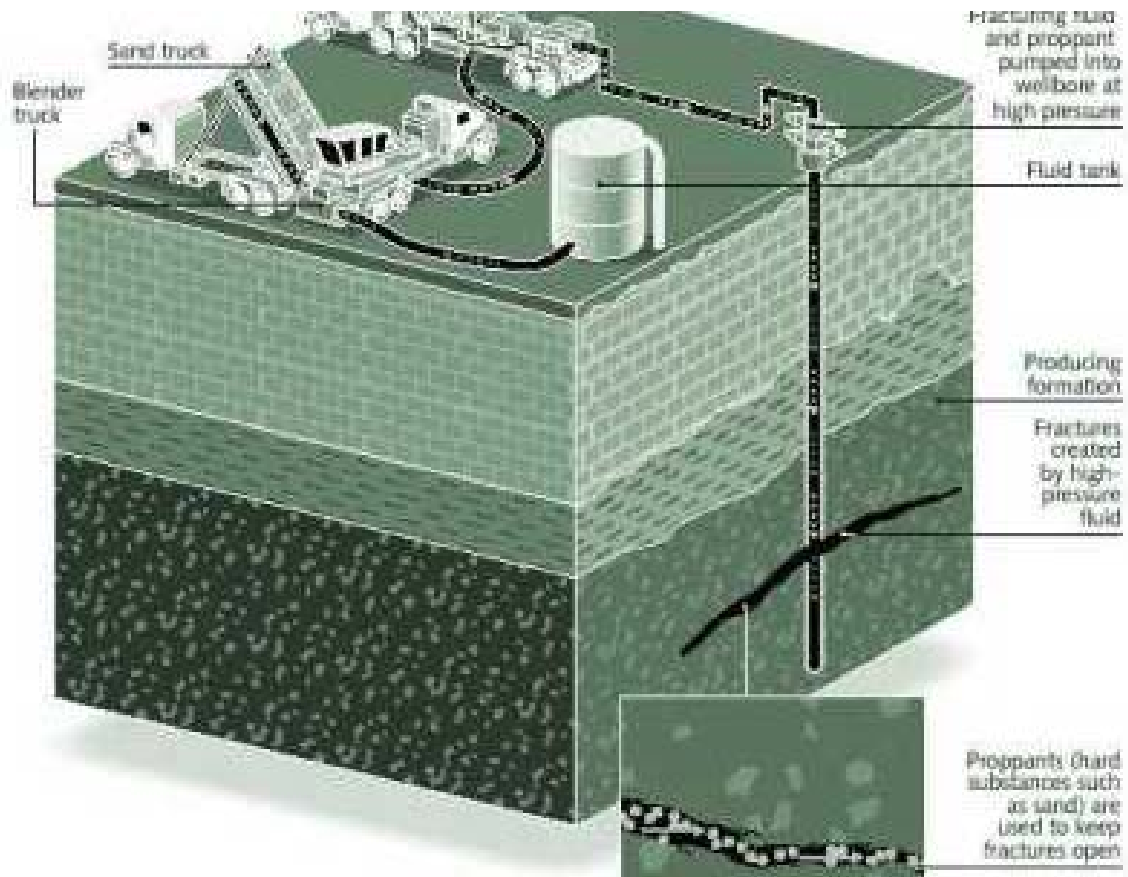
Directional Drilling in Garfield County



Background

- Piceance Basin (13bcf/d)
- Natural gas boom since ~2000
- Garco 3000 mi²/50,000 residents
- 16 operators
- 20 active rigs now-72 at peak in '08





Does fracing/frac'ing/fraccing/fracking contaminate groundwater?



Fracking

- 2009 GWPC testified/published document- no contamination from fracking
- Not = no contamination from oil and gas
- Contamination resulted from:
 - operator errors
 - bad cement jobs
 - waste pits

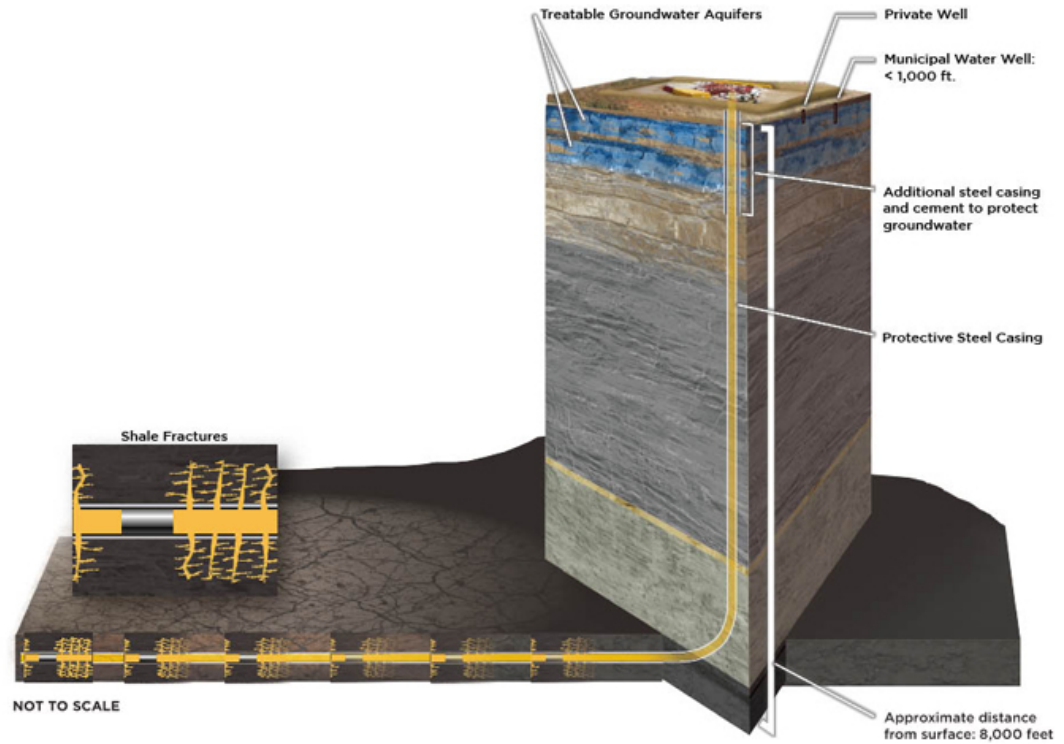
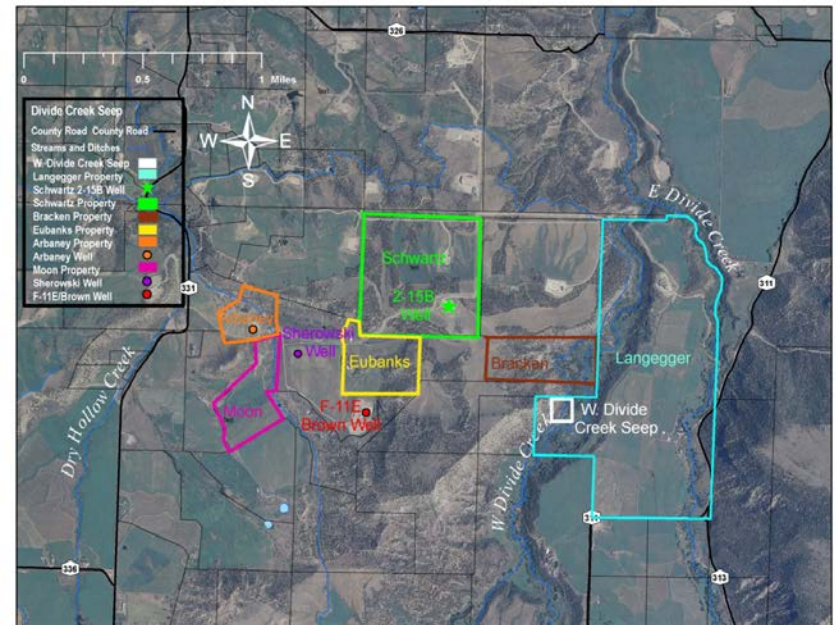
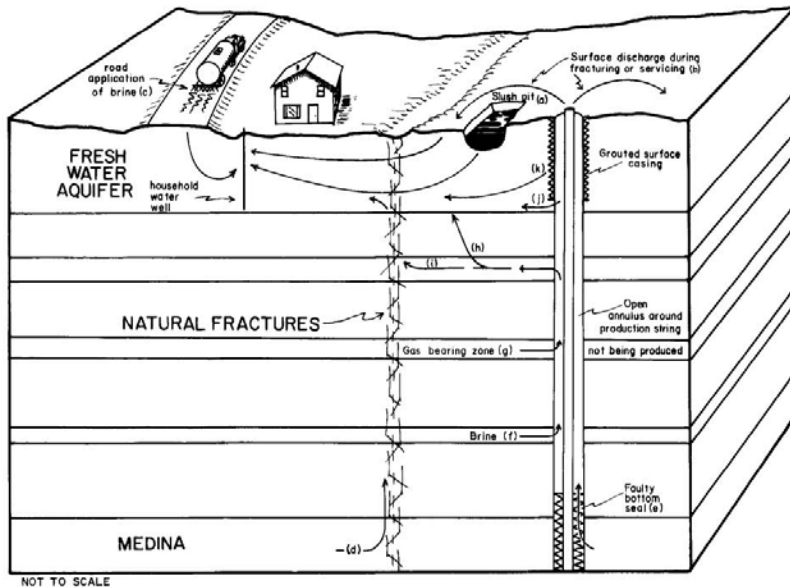


Figure from Chesapeake Energy
(<http://www.hydraulicfracturing.com/Pages/information.aspx>)



Gas moves up through uncemented annulus of well to fracture nearer to surface and exits through West Divide Creek



Mamm Creek Study – Phase I

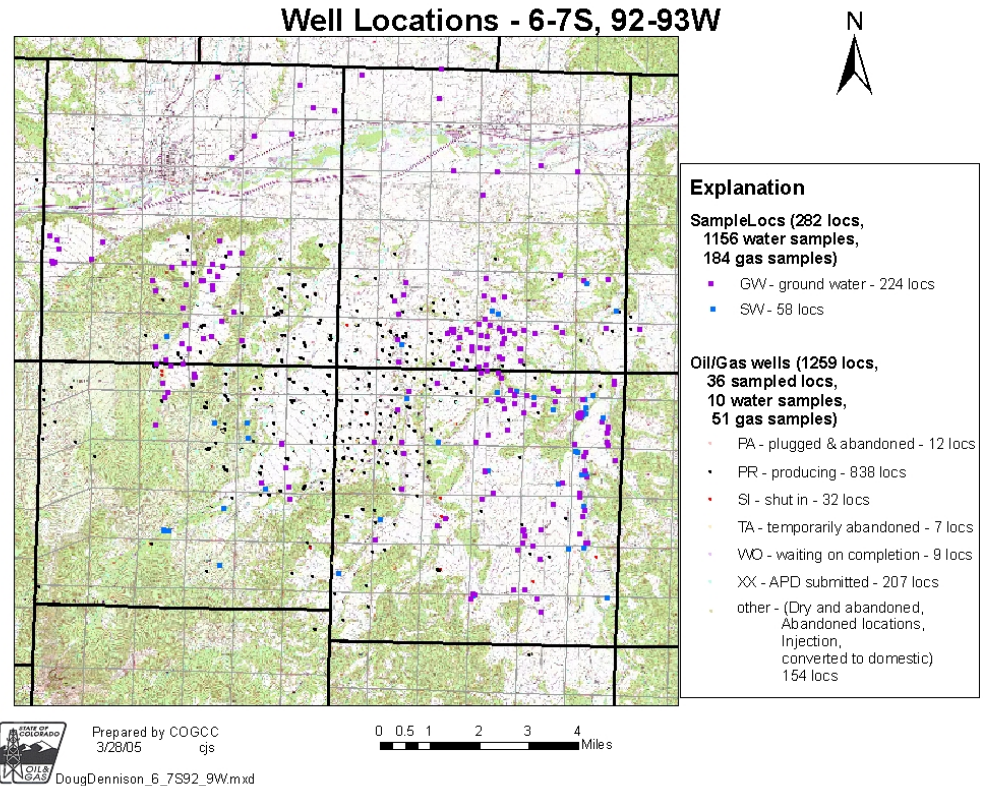
•Studied

- WQ Reports
- Gas Well Logs
- Water Well Logs
- Geologic Reports
- Rock Outcrops
- Aerial Photographs

•Mapped

- Water Table
- Gas Wells
- Water Wells
- Bradenhead Pressures
- WQ Trends
- Etc.

•Identified contaminants

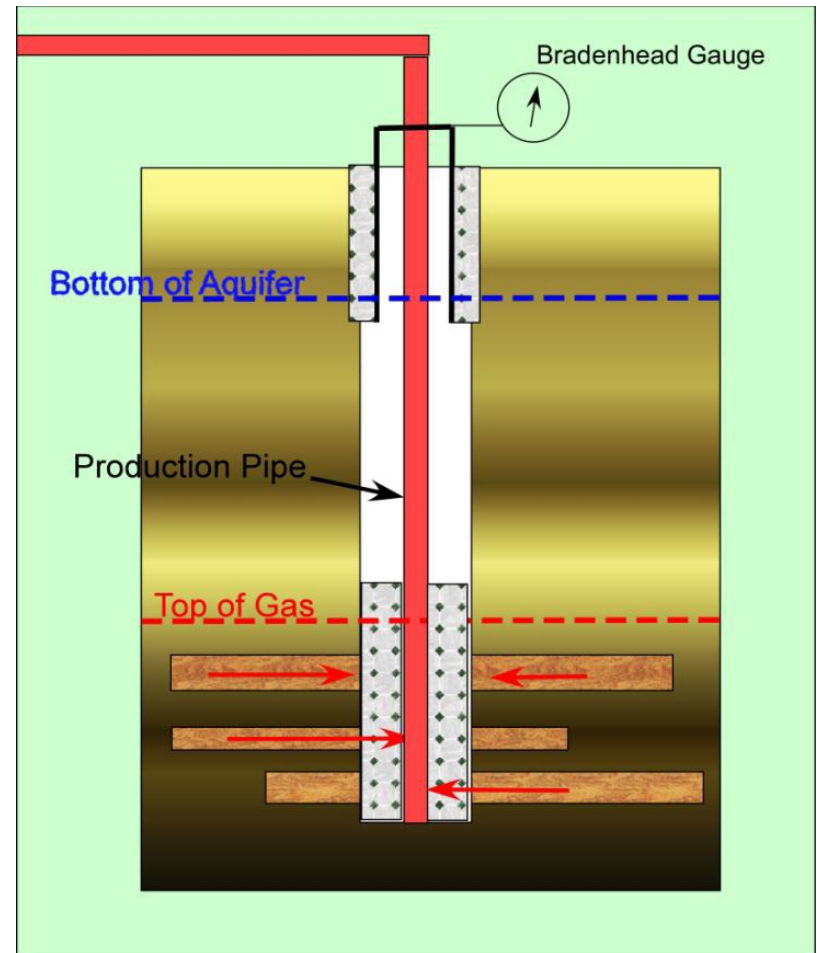
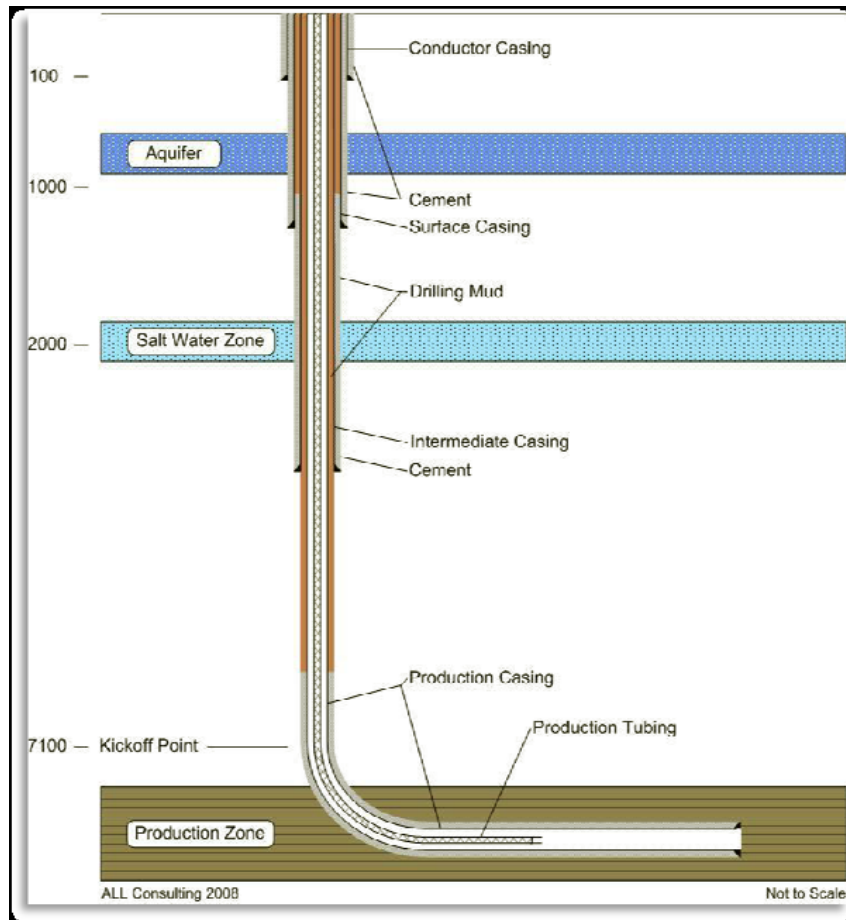


Mamm Creek Hydro Study Phase II

- Sampled domestic wells
- Isotopic analysis of methane (CH_4)
 - $\text{C}^{13} : \text{C}^{12}$ ($\delta^{13}\text{C}$)
 - $2\text{H}:1\text{H}$ (deuterium and protium)
- Found thermogenic methane
- Source?
 - Biogenic (current microbial process)
 - Thermogenic (ancient geologic process- heat and pressure over millions of years)
- What about propane, ethane, butane, BTEX?



97 wells not cemented to “standard,” which is questionable (opinion) - Definition of “bottom of aquifer” - Right: Based on stratigraphy/hydrogeology
Wrong: Default to deepest water well depth





Conclusions?

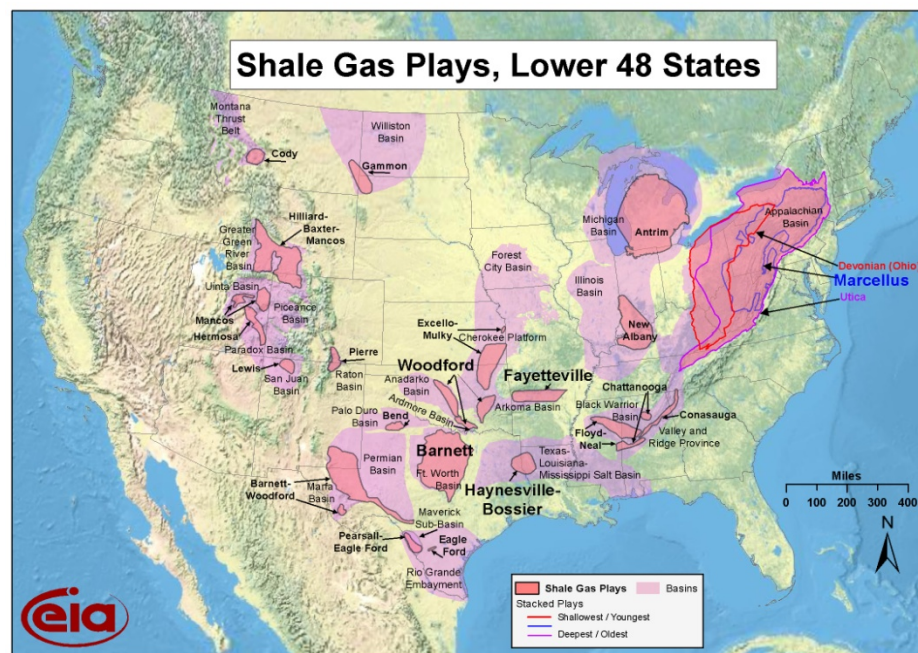
- Thermogenic methane in groundwater
- Nearly all wells uncemented at least ~2000 ‘
- Area is highly fractured
- Overpressured formation (i.e., perfect indication of a resource “trap”)
- High bradenhead pressures in gas wells
- Yet COGCC still allows wells to be left unsealed within the Wasatch aquifer even in new wells

"It has been said that if one laid all the world's ~~economists~~ hydrogeologists end to end, they wouldn't reach a conclusion."



Water Concerns Water Concerns Everywhere

- Residents of TX, AR, PA, NY, CO clamoring about water & air contamination
- Moratorium in NY til April 2011
- Organizing in AR, TX, PA
- Heinz Fdn \$2MM grant to fund baseline study
- Garco citizens ask BOCC to oppose downspacing

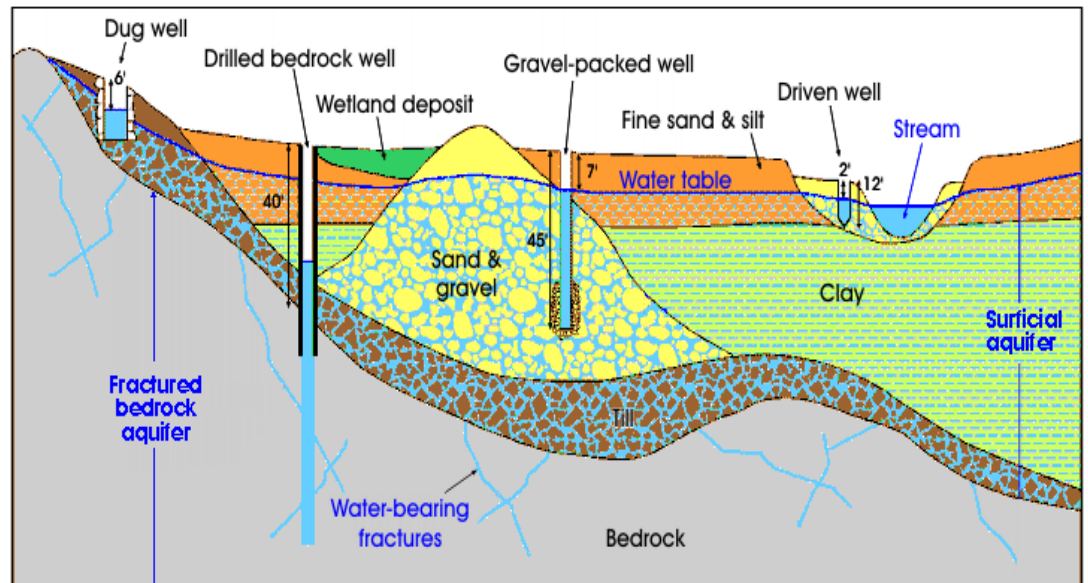


Source: Energy Information Administration based on data from various published studies.
Updated: March 10, 2010



The FRAC Act and EPA's Study

- Started with FRAC Act and EPA sampling in Pavillion WY
- Purpose to investigate potential impact of fracing on WQ and public health
- Developing study plan with guidance of SAB
- Results due by end of 2012



How are eastern shales like western tight sands?



From the film "Gasland" by Josh Fox

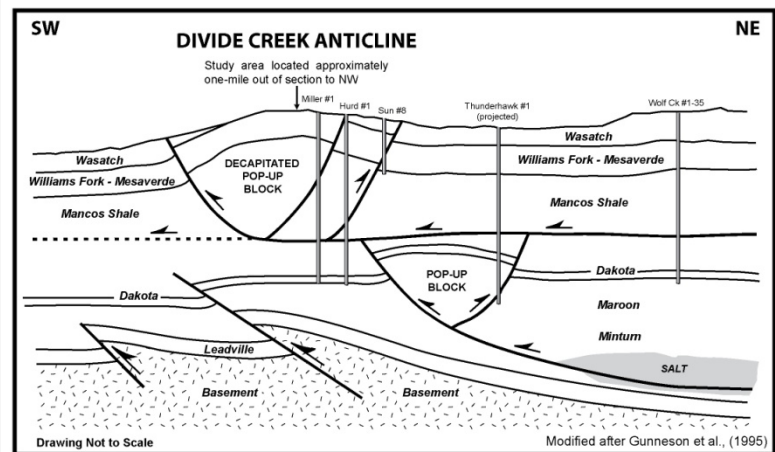
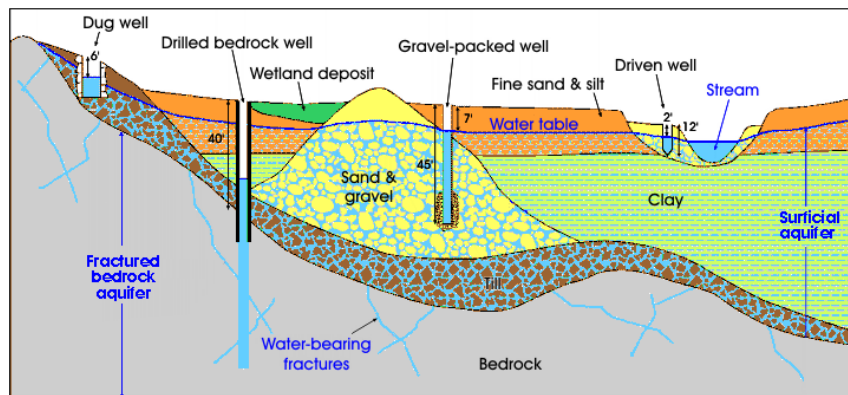


Answer:

They're not;
they're in the
east!

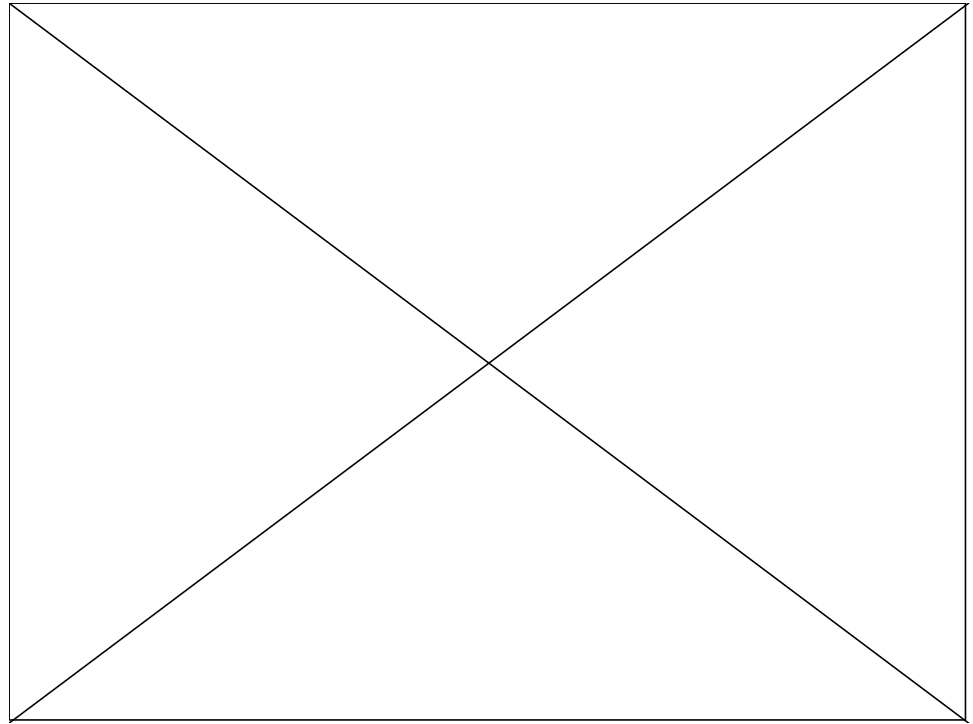
And we're not in
Kansas anymore.





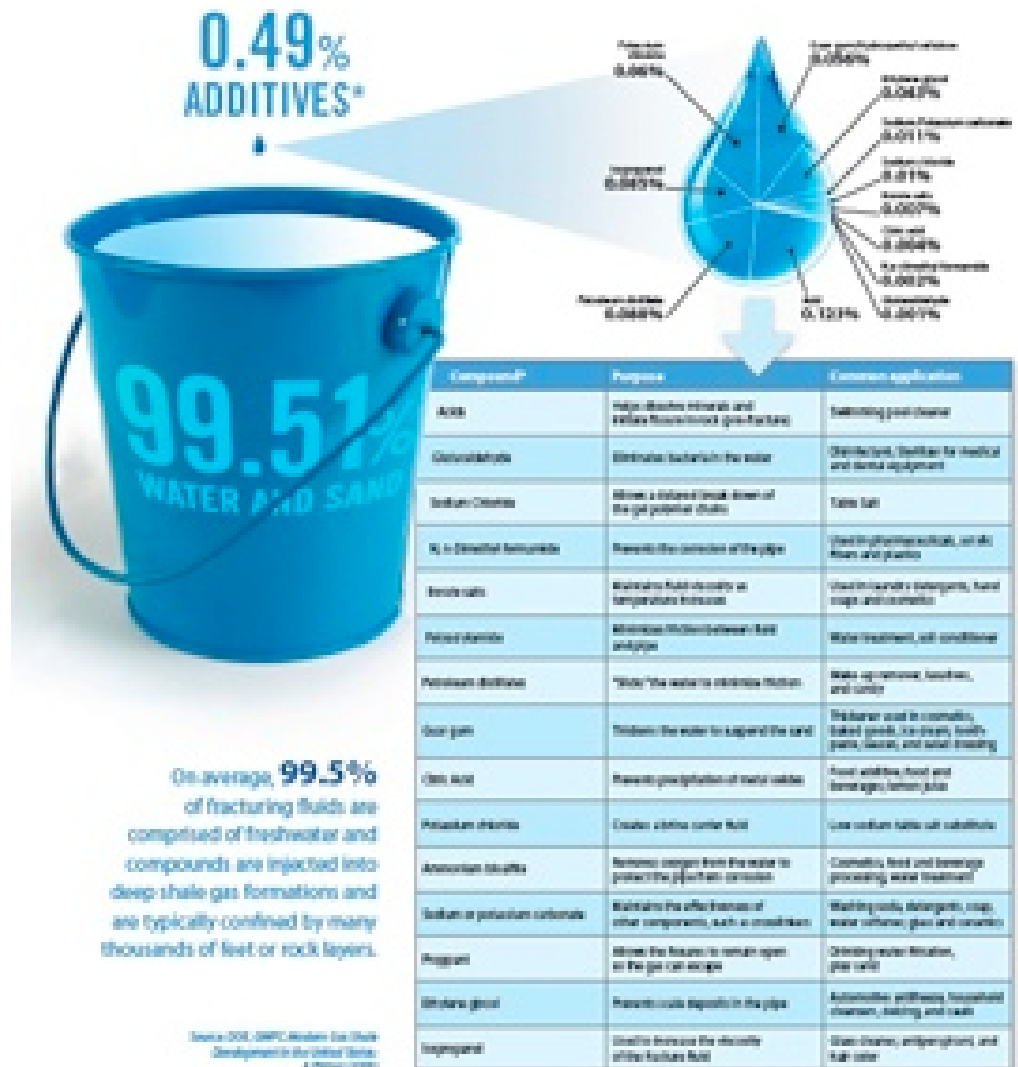
Schematic interpretation of Divide Creek Anticline and related producing fields. In the interpreted sequence of structural development, the shallower pop-up anticline was decapitated and thrust westward due to later thrusting from the east along the Mancos detachment, leaving the deeper pop-up block to the east. A deeper, basement-involved structure is also present to the east.

Animation of fracturing from Youtube



- Hydrocarbons include:
 - Methane (CH₄), Ethane (C₂H₆), Propane (C₃H₈), Butane (C₄H₁₀), pentane (C₅H₁₂) and hexane (C₆H₁₄)
 - BTEX (Benzene, Toluene, Xylene, Ethylbenzene)
 - +
- Fingerprinting not exact – different degradation

A FLUID SITUATION: TYPICAL SOLUTION* USED IN HYDRAULIC FRACTURING



What are the odds?

(1/66,000,000 vs 1/97)

EON	ERA	PERIOD	MILLIONS OF YEARS AGO
Phanerozoic	Cenozoic	Quaternary	1.6
		Tertiary	66
	Mesozoic	Cretaceous	138
		Jurassic	205
		Triassic	240
		Permian	290
	Paleozoic	Pennsylvanian	330
		Mississippian	360
		Devonian	410
		Silurian	435
		Ordovician	500
		Cambrian	570
			570
Proterozoic	Late Proterozoic Middle Proterozoic Early Proterozoic		2500
Archean	Late Archean Middle Archean Early Archean		3800?
Pre-Archean			

- 97 wells constructed with no cement to bottom of aquifer
- 2000 wells with cement only to “bottom” of aquifer + 50 (i.e. 600 feet when aquifer is 1000-2000 feet thick)

Mamm Creek Phase I

“Let me see, should I pick this one or this one, or, gee this looks good.”

- Methane in GW could come from
 - natural migration in fractures, or**
 - oil and gas development, or**
 - coalbed methane development**

Relevant Findings:

- Geology highly fractured
- Groundwater contains NG-related contaminants
- Gas bearing Fm (Williams Fork) is overpressured
- Numerous old wells improperly constructed



West Divide Creek 2004

- Lost cement in Schwartz well
- Tried to repair
- Gas seeped into WDC
- State issued fine
- \$ was applied to Mamm Creek Study

